

west. Aransas Pass gas and whistling buoy, weight 8,000 pounds with an anchor weighing 5,000 pounds and 252 feet of anchor chain weighting 3,528 pounds (total weight 16,528 pounds) in 42 feet of water was carried 5 miles across the right front and somewhat in toward the coast. This buoy was located in latitude $27^{\circ}50'$ and longitude $97^{\circ}02'$ about 50 miles to the right of the line followed by the center of the cyclone.

The destructive power of the storm swell is brought out in this cyclone. At Sabin Bank Light House, about 125 miles to the right of the line followed by the center

of the cyclone, cast iron plates five eighths inch thick, 27 feet above the surface of the water, were bent up and crushed in by the storm swells.

Currents developed by a tropical cyclone when approaching the coast run across the right-hand front of the storm in toward the coast and contribute to the building up of the tide which is the destructive feature on the coast. In cyclones traveling coastwise, currents of considerable force are developed more than 125 miles to the right of the path of the center of the storm and run nearly parallel to the coast.

A BRIEF STUDY OF OREGON TEMPERATURES

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Four factors are prominent in the control of temperature in Oregon, namely, latitude, altitude, nearness to the ocean, and local topography. Of these factors nearness to the sea is the most important, and altitude comes next. While the State extends through more than 4° of latitude, it is probable that when everything is taken into consideration local topography will be found to be almost as important as latitude.

For this reason no discussion of Oregon temperature will be complete without reference to the geographical and topographical features of the State.

Oregon lies mostly between the forty second and forty sixth parallels, or in the latitude of northern Italy and southern France. It extends from the Pacific Ocean inland for 375 miles. The area is 96,699 square miles, including more than 1,000 square miles of water surface. This is an area greater than that of New England, New Jersey, Maryland, and Delaware, taken together.

In altitude it ranges from sea level to more than 12,000 feet. Within the city of Portland alone there is a range of more than 1,000 feet, or more than in the combined States of Illinois and Indiana.

The most prominent topographical feature is the Cascade Range of mountains, extending from north to south, with a little less than one third of the area lying to the westward. This range includes several snow-clad peaks, the highest of which, Mount Hood, rises to an elevation of 11,225 feet. The only low pass through the Cascades is the one formed by the Gorge of the Columbia River, at the northern boundary of Oregon. This gorge is cut through nearly to sea level. It is known around the world for its beauty and for its utility in providing an all-year gateway for water, rail, highway, and air transportation. It also forms a remarkable gateway for the transportation of weather, and is one of the most interesting out-door meteorological laboratories in the world.

Next in importance is the Coast Range, extending near and parallel to the coast. For most of its length this range is relatively low, but toward the south it includes some high, rugged country, and is partially connected with the Cascade Mountains by a stretch of rough, hilly country. Within this hilly region there are numerous sheltered valleys, but no wide expanses of open country. Toward the north the Cascades and Coast Range are separated by the broad Willamette Valley, which is in itself a series of connected valleys.

The term "Blue Mountains" is rather loosely applied to a group of irregular mountain masses covering much of the northeastern quarter of the State, but in that

quarter there are some broad valleys and much rolling agricultural land.

The southeastern quarter of the State is largely a great plateau, 4,000 to 5,000 feet above sea level, but from this plateau several mountain groups rise, and there are several lakes, mostly shallow and brackish, which have some local effect on climate. There are a few deep canyons, but streams are few and mostly small, losing themselves in flats or marshes, or emptying into lakes having no outlets.

The Japan current has long been given unwarranted credit for the mild climate of western Oregon. However, the marine influence is the prime factor in the control of temperature west of the Coast Range, an important though less evident factor in the Willamette and other western valleys, and a less important but noticeable factor east of the Cascades.

Fortunately in the latitude of Oregon westerly winds predominate, and therefore the modifying effect of the ocean is greater than it would be otherwise. On the rather rare occasions when strong east winds blow the continental influence may extend to the coast. Such occasions are all the more noticeable because they are unusual.

Considering only places where reliable records have been kept, the normal annual temperature ranges from about 56° in the lower Snake River Canyon, in the extreme northeast, to about 38° in the high Cascade Mountains. There are of course areas higher than any of the meteorological stations, which have still lower temperatures.

As shown at recording stations, the range in annual temperature is greater than that found in going from Mobile, Ala., to Boston, Mass., or along the immediate coast from California to Alaska. The mean temperature of the warmer sections is like that of northern Texas, while that of the cooler portions compares with that of extreme northern Montana. In all parts of the State there are marked local differences in temperature. Even within the city limits of Portland there are found, at times, pronounced differences in temperature within a few blocks.

While these differences in normal annual temperature are striking, a description of them falls very far short of telling the whole story of temperature distribution. For example, Brookings, in the southwestern corner, and Pendleton, near the northeastern corner, have the same normal annual temperature, but at no time in the year are conditions at the two places similar.

Comparison of the normal minimum temperatures for January gives a measure of the relative severity of the

winters. While there is a range of about 18° in the normal annual temperatures in different parts of the State, the range in normal minimum temperatures for January amounts to more than 28° , or from 12° to 40° . The mildest winter nights are found on the southern coast, as is to be expected, but the greatest of extremes of cold are not in the mountains but over the high plateau regions, where the air is dry, air drainage rather poor, and conditions favor rapid cooling by nocturnal radiation. There are many local irregularities in the distribution of minimum temperature which cannot be shown on a map, but there are some which are sufficiently prominent to be quite noticeable. It has already been stated that the southern end of the Coast Range is higher than the northern, and that these Coast and Cascade Ranges are partially connected. This condition, together with high mountains in northern California, creates a temperature shadow to the east of the southern Cascades, where low minimum temperatures are common. The writer has seen Upper Klamath Lake entirely frozen over when some of the smaller lakes farther north, near the summit of the Cascade Mountains, were free from ice. A rather mild belt extends along the middle reaches of the John Day River, probably caused in part by foehn conditions. Another mild belt is in the vicinity of Summer Lake. This lake is shallow and would seem unimportant meteorologically, but peaches are grown in coves in the mountains west of the lake, at an elevation of about 4,500 feet.

Summer maximum temperatures show a still wider variation than winter minima. The coolest summer days are on the middle and southern coast. This is due largely to the direct cooling effect of the ocean, which is particularly cold in summer along the southern Oregon and northern California coast. A secondary cause is the prevalence of fog and clouds, which retard the diurnal rise in temperature. The highest temperatures in summer afternoons are along the middle reaches of the Columbia River, in the extreme north, and in the deep canyon of the lower Snake River, in the extreme northeast. The range of normal maximum temperature in July is from about 65° to 95° , which is greater than that for the entire United States east of the Rocky Mountains.

As an example of the contrast in temperature distribution in different parts of the State the following may be cited. In the year 1921 the highest temperature at Newport was 70° and the lowest 18° , making a range of 52° for the year. At Blitzen in that same year the maximum was 103° and the minimum was -50° , making a range of 153° . At Blitzen on August 22 of that year the maximum was 99° and the minimum 33° , making a range for the day of 66° , exceeding the annual range at Newport by 14° .

At certain times the temperature differences over the State are much more pronounced than would be indicated by reference to mean values. On July 30, 1929, which was a particularly hot day, the maximum at Brookings was 63° and at Pittsburg Landing, in the Snake River Canyon, 111° , making a range of 48° .

If often happens in summer that high temperatures in the interior are attended by low temperatures on the coast, and this calls to mind a current saying to the effect that hot spells in the Willamette Valley never last more than 3 days. This is not altogether true, but in the last 40 years there have been but eight times when the temperature at Portland has reached 90° for more than 3 days in succession. The average duration of such periods is 2 days. Persistence of high temperature in the interior of western Oregon for 2 or 3 days usually results in the northward extension of the Arizona Low into Oregon;

this in turn is followed by an indraft of cool air from the ocean which marks the close of the hot period. In southern Oregon, where the Coast Range is higher, warm periods last longer and maxima are higher. East of the Cascades warm periods are more persistent.

Under extreme conditions in winter temperature differences over the State may be even more pronounced than in summer. On January 21, 1930, one of the coldest days ever known in Oregon, the minimum temperature ranged from 38° at Brookings to -52° at Danner, a total range of 90° . In such times the lowest temperatures are usually in the open valleys and over the plateau.

Such extremely cold weather occurs only as the result of the rapid southward movement of an Arctic high into the plateau region. This movement is attended by a marked fall in temperature, particularly in eastern Oregon. Extremely low temperatures occur a few days later, when the Arctic air is still further cooled by radiation. Such movements are attended by strong east winds through the Columbia River Gorge, but these east winds in winter are shallow, and as a rule do not cross the Cascade Mountains in any great volume. It might be expected, therefore, that the lowest minimum temperatures in western Oregon would be experienced near the mouth of the gorge, but this is not the case. In this instance the lowest minima were in the Willamette Valley, about 55 miles south of Portland, and in the Tualatin Valley, about 30 miles west of Portland. Still lower minima were recorded on lowlands along the Columbia about 50 miles north of Portland, on the Washington side. The cold air which comes through the gorge under these conditions is moving rapidly and there is little opportunity for the formation of marked temperature inversions until the air has spread out and become quiescent. As soon as it does become quiescent there is a rapid nocturnal fall in temperature near the ground, for this continental air is dry, and the sky is usually clear.

On the break-up of a cold period conditions are somewhat reversed. When warm south winds begin to blow over western Oregon following a cold snap there is usually still a slow drainage of cold air through the gorge for a day or two. The warm current overrides this cold air at first, and Portland will remain cool when normal temperatures have been reestablished to the north as well as to the south. Under extreme conditions south wind has been observed at the tops of some of the tall buildings while the wind in the streets was still from the east.

Mention has already been made of the fact that the cold east winds are shallow. Under certain pressure conditions these shallow cold winds may be overrun by great masses of warm, moist air, so that higher temperatures prevail in the mountains than in the valleys. An extreme condition of this kind was observed in November 1921 when there were heavy warm rains at high levels in the Cascades, with a noticeable decrease in snow cover, while sleet was falling and ice was forming in and near the Columbia Gorge.

When high-pressure areas move in from the Pacific and become established over the Plateau region, they cause cold weather in eastern Oregon, but extremes are much less pronounced than in the case of the southward movement of Arctic highs. The plateau highs often remain nearly stationary for considerable periods. This was particularly true in December 1930 and during that month temperature in eastern Oregon, while not extremely low at any time, averaged much below normal. The deficiency reached 7° along the eastern boundary.

A large part of the area west of the Cascades had temperature near or above normal, and instead of the cold weather of eastern Oregon extending through the gorge into the western portion the reverse seems to have been true, for a number of places along the Columbia River east of the Cascades had temperature slightly above normal.

It is difficult to determine the length of the growing season in the colder parts of Oregon, for over those regions agriculture is mostly confined to the growing of the hardier crops; moreover, in regions where the nights are so uniformly cool even the less hardy crops seem to develop a degree of resistance to frost. The records of killing frost show that over most of the region west of the Cascades the length of the growing season is more than 150 days, reaching 250 days on the coast. In the principal agricultural districts east of the Cascades it is between 100 and 200 days. Some of the high plateau districts have less than 50 days, and there are regions where frost may occur in any month of the year. However, even in these regions considerable areas are devoted to agriculture, and even some potatoes and garden vegetables are grown.

A preliminary study of the frequency of temperature changes in different parts of the State has given some interesting results, and it is planned to continue these studies as opportunity offers.

At Portland the changes from one 5 a.m. observation to the next are mostly very small. There is little chance of a verifying change and no chance at all of a verification of a cold-wave warning. In the last 10 years the extreme change has been 21°, and this was a plus change; 95 per cent of the changes have been less than 10°.

The changes from one p.m. observation to the next at Portland have been somewhat greater, but even here in the last 10 years 88 per cent of the changes have been less than 10°, with an extreme of 32°. The greater p.m. changes are quite largely the result of the passing of brief warm periods in summer, and are not the result of the passing of cyclones with well-defined warm and cold fronts.

At Baker, fairly representative of eastern Oregon, the data for the 5 a.m. observations for the last 10 years show a much greater prevalence of large changes. Many of these changes occur in winter, but they may occur at any time. Conditions at Baker are often favorable for rapid cooling by nocturnal radiation, and the local topography favors marked inversions. Because these temperature changes are so largely local they are rather hard to forecast.

Data for the 5 p.m. observations at Baker show a still greater probability of large changes, particularly minus changes. Many of these large changes occur in summer.

No discussion of Oregon temperature would be complete without reference to humidity in its relation to tempera-

ture. In the nature of things hot weather in Oregon must be dry weather. Low humidity is the normal summer condition east of the Cascades; extremes of heat west of the Cascades occur only when warm dry air is brought from the interior. For example, in August 1930 which was an unusually warm month at Portland, the reading of the wet thermometer at the 5 p.m. observation did not exceed 70° at any time. The fact that warm periods are also dry renders them less uncomfortable than they otherwise would be.

On the other hand, such cold periods as occur in western Oregon in winter are more noticeable because they are dry. This is particularly true near the mouth of the Columbia Gorge, where cold weather is usually attended by drying east winds, which are in marked contrast to the usual mild, moist winds from the ocean. For example, on the unusually cold day already referred to, January 21, 1930, the relative humidity at Portland was 40 per cent, as compared with a normal of 87 per cent.

In ordinary winter weather at Portland humidity is sufficiently high to simplify the matter of conditioning air in residences and public buildings. The same statement holds true over most of the State, though in a less degree in eastern districts.

A good deal is said from time to time about progressive variations in temperature from year to year. Portland has a complete record for nearly 60 years; the record for Roseburg covers more than 53 years, and that for The Dalles, though somewhat broken in early years, is nearly continuous for the last 56 years. Walla Walla and Boise, just outside the boundaries of the State, have somewhat longer records than Portland, though at Boise part of the records were kept at the military post, just under the foothills, and for this and other reasons may not be strictly comparable with the records now being kept in the city proper. These five records show fair agreement with one another. The most pronounced features are two warm periods, the first culminating in the early seventies and the second about 1926, and two cold periods, the first culminating about 1879 near the coast and about 1883 near the eastern boundary, and the second, somewhat less pronounced, about 1894.

It is generally conceded that as cities grow up around meteorological stations the recorded temperatures are somewhat too high. If this is true it would be expected that the Portland record would show some tendency toward higher temperature in the later years, as compared with records kept in smaller cities. It is found, however, that the later warm periods are quite as pronounced at other places as at Portland. There is very little in the records for any of the stations to indicate a progressive change in temperature.

THE SUMMER NIGHTTIME CLOUDS OF THE SANTA CLARA VALLEY, CALIF.

By EDWARD H. BOWIE

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The decision of the United States Navy to make its Pacific coast base for airships in the Santa Clara Valley, Calif., in the vicinity and slightly to the north of the Weather Bureau station in San Jose, at a point known as Sunnyvale, is of particular interest to American meteorologists. Apparently this decision was reached only after an extended survey of this and other proffered sites for a Pacific coast base. What the findings and recommendations of the aerologists who made these surveys are is not

known to the writer. It is to be assumed, however, that they were aerologically favorable to it, and doubtless led to the decision to recommend the Santa Clara Valley site. This site having been selected, it follows that any information concerning the climate and the day-to-day regime of weather in the vicinity of Sunnyvale base cannot fail to be of interest to the climatologist and to the meteorologist.

This study has been restricted to the daily regime of cloudiness in the summer months in the vicinity of San